Impact of Guar Gum Derivatives on Properties of Freshly-Mixed Cement-Based Mortars

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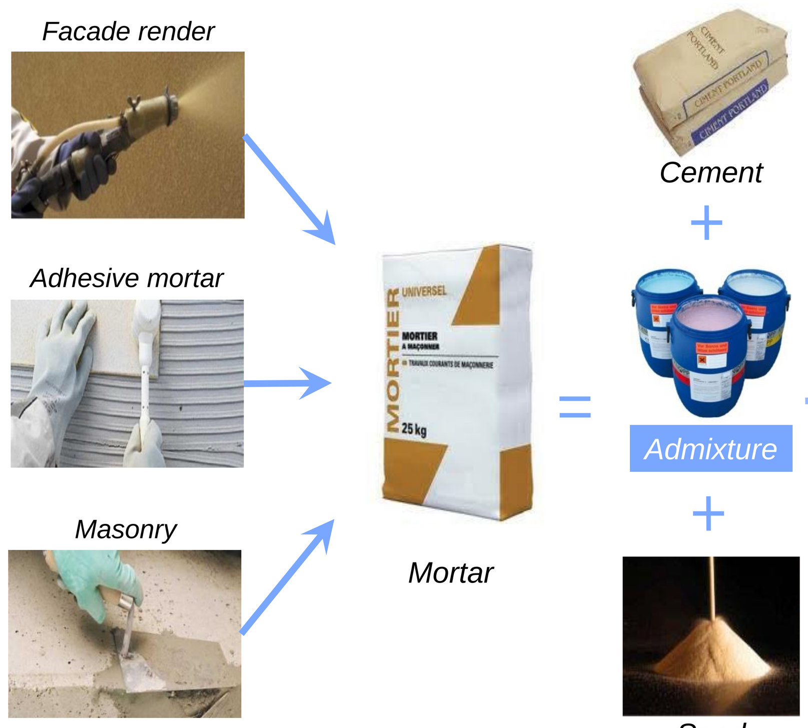


Water Retention Agent
(polysaccharide)

Most widely used admixture: ***Cellulose Ethers***

~ **1/3 of** raw materials **cost** for only **0,5 wt%**

Desired Effect

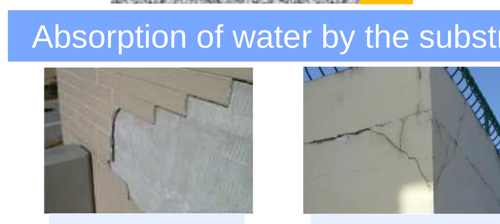
Water Retention

= Capacity of fresh mortar to keep its mixing water

With Water Retention Agent | Without Water Retention Agent

Mixing water stay into the fresh mortar → Good Mechanical and adhesive properties

Absorption of water by the substrate



Adhesion failure | Cracking

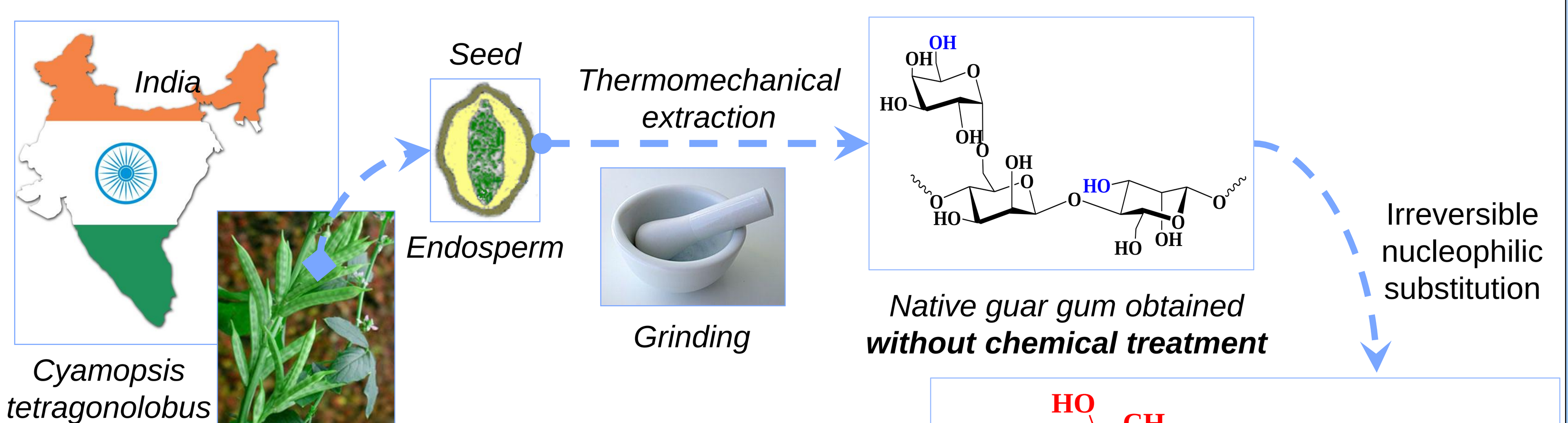
Polysaccharides are also expected to act as VEA

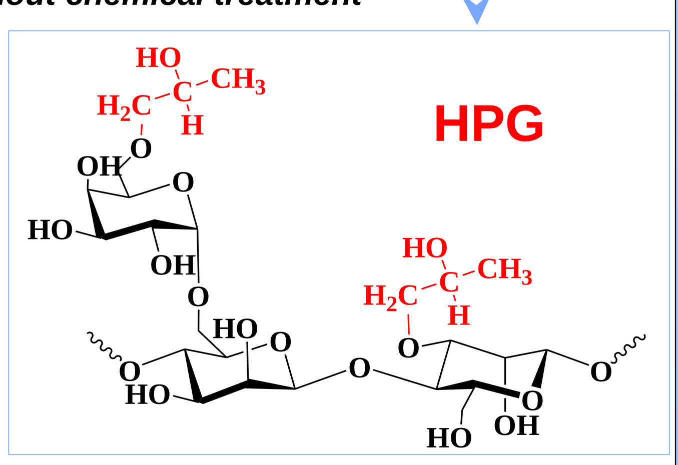
Major drawback: Cement hydration delay

Study of bio-based Water Retention and VEA admixture : Hydroxypropyl Guar (HPG)

Materials

HydroxyPropyl Guars





HPG preparation

HPG Studied

- A **native Guar Gum** (**GG**) + **3 HPGs** + **2 hydrophobically modified HPGs**
- Roughly the same molecular weight (≈ 2.10^6 Da)

Sample	MS_{HP}	Additional Substitution	DS_{AC}
HPG 1	Low	-	-
HPG 2	Medium	-	-
HPG 3	High	-	-
HPG 4	High	Short alkyl chain	
HPG 5	High	Short alkyl chain	Higher than HPG 4
GG	-	-	-

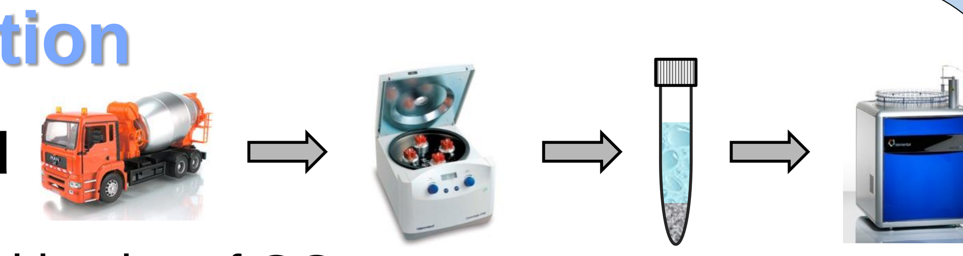
Mortar Formulation

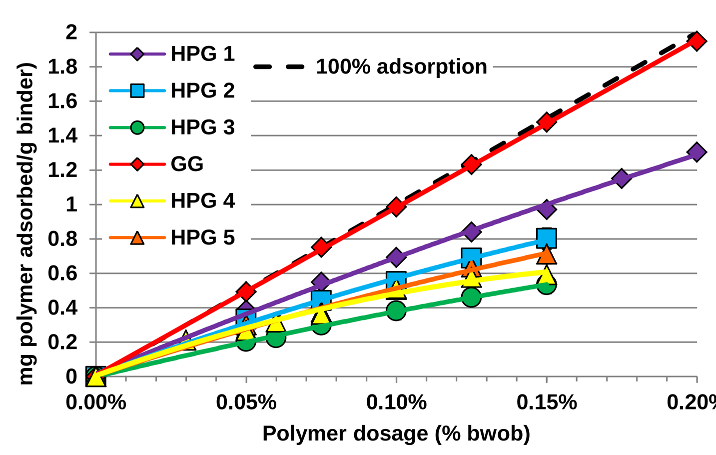
Component	CEM II/B-LL 32.5R	Lime	$CaCO_3$	$CaMg(CO_3)_2$	Water
% mass of dry mixture	12 %	3 %	18 %	67 %	22 %

- Water-to-Binder ratio: **W/B = 0.22**
- Admixtures in addition to the binder: **0.05% – 0.15% bwob**

Adsorption

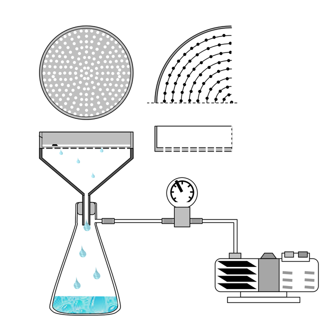
TOC - Centrifugation - Depletion method



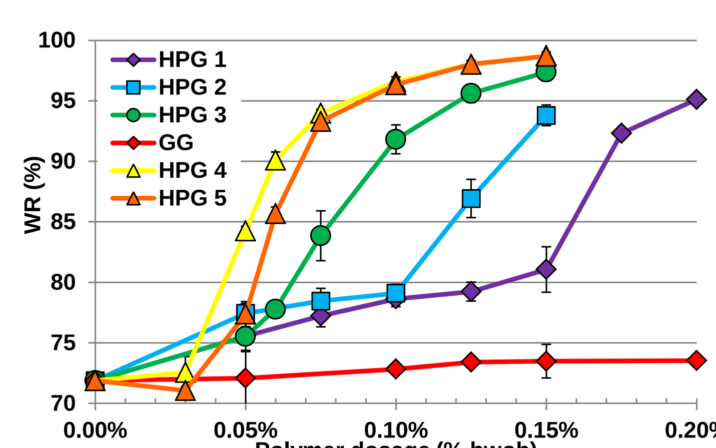


- Low dissolution kinetics of GG
- ↗ MS_{HP}: ↘ Adsorption because of ↘ free -OH and polarity
- Hydrophobic alkyl chain: Low ↗ Adsorption
  Change in conformation of HPG (Simon et al.)
  Alkyl chains inside the coils / Hydrophilic groups at the outskirt of the coils

Water Retention



Standard ASTM C 1506-09: $$WR(\%) = \frac{W_0 - W_1}{W_0} \times 100$$

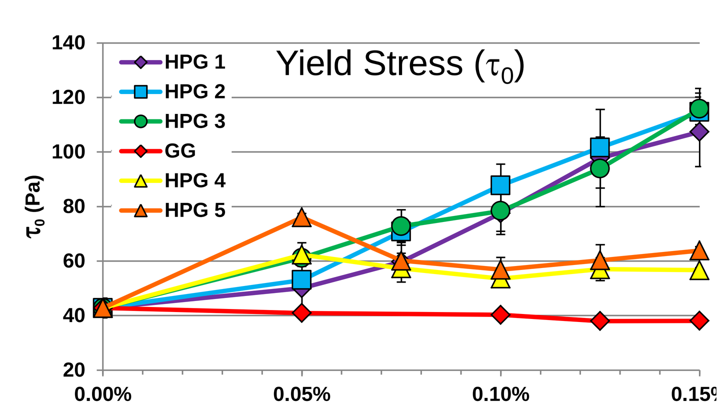


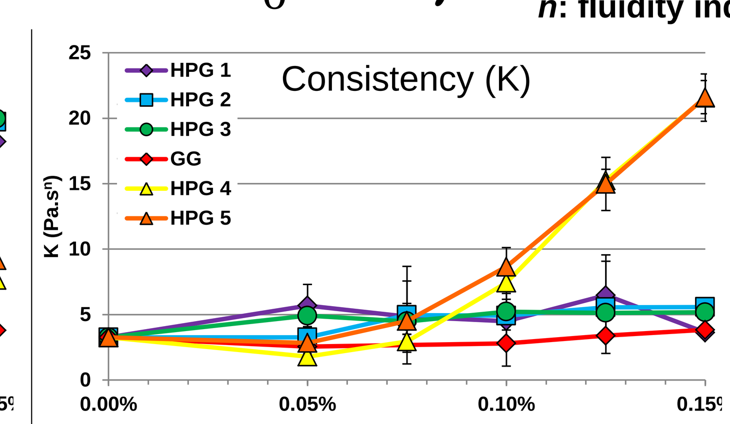
- Excepted **GG**, **HPGs improve** the WR capacity of mortars
- ↗ MS_{HP} **improves** the WR capacity $MS_{HP\ HPG\ 1} < MS_{HP\ HPG\ 2} < MS_{HP\ HPG\ 3}$
  Thanks to ↘ Adsorption and thus ↗ [HPG] in pore solution
- **Positive impact** of the additional **alkyl chain**
  ↗ Adsorption compensated by ↘ in coil overlapping concentration
- ↗ DS_{AC} slightly **reduces** the WR capacity $DS_{HP\ HPG\ 4} < DS_{HP\ HPG\ 5}$

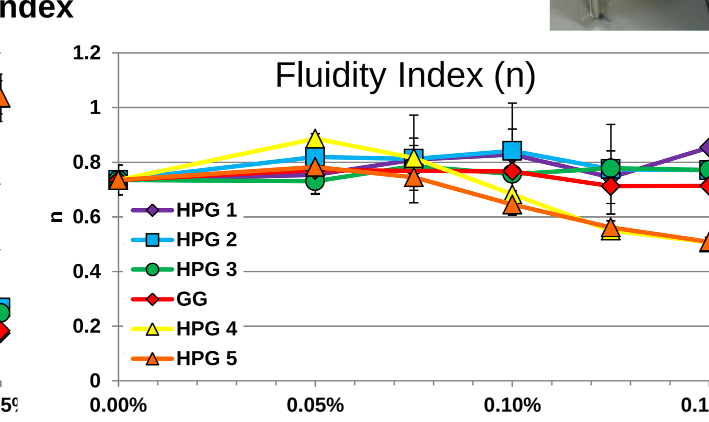
Rheological properties of mortars

Herschel-Bulkley model: $$\tau = \tau_0 + K\dot{\gamma}^n$$

τ_0: yield stress
K: consistency coefficient
n: fluidity index







- ↗ τ_0 **with HPGs 1, 2, 3**
  Bridging flocculation
- ↗ MS_{HP} ↘ adsorption ↘ bridging **compensated by ↗ η_0 and [HPG]**

- ↗ K **and** ↘ n **with HPGs 4, 5**
- **Rheological behavior of mortars imposed by the more and more shear thinning behavior of pore solution**

Conclusions

Water Retention

- HPGs are good water retention agents
- Huge impact of HPG chemical composition
  → ↗ MS_{HP} promotes WR by ↗ [HPG]
  → Hydrophobic side chain promotes WR by ↘ C*

Rheological properties

- HPGs act as VEA
- → “Classical” HPGs ↗ the stability of mortars by ↗ τ_0
  → Hydrophobically modified HPGs ↗ the resistance to the flow of admixed mortars by ↗ K

Chemical composition of HPGs is a key parameter of mortar formulation